Communication Technologies for Energy Management and Energy Services

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ABSTRACT

Current advances in communication and information technology make it possible for utilities and energy service companies to provide new energy services to their customers ranging from load management strategies to remote diagnostics and energy efficiency monitoring of electricity consuming appliances. This paper presents the current technological development in the information and communication technology area for the one- and two-way communication between the electricity provider and the customer. The paper describes existing and future energy-related services and the communication infrastructure necessary for delivering the services.

Discussed are new market trends in the controls, communication, and utility industry that focus on energy management integration between the utility or energy provider and residential, commercial and industrial customers. In particular, we focus on potential and new information services that are likely to be offered by the utility industry to generate new revenue sources. We describe the concept of dynamic demand bidding and discuss the procedural protocol for the operation in a competitive market environment.

Introduction

Advances in communications technology combined with the current national and international developments toward competitive market structures in the electric power industry have brought innovative services and products to fruition. Thus products and services are being offered today both by traditional utilities and joint ventures between utility subsidiaries and technology companies. To date the largest and perhaps most profitable communication service is the automated meter reading application, but other services can be envisioned that could provide the utility with new sources of revenue and may improve the overall energy efficiency in both the power generation and end-use sectors.

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This paper characterizes some enabling technologies that support available and future energy information services including automatic meter reading, direct load management, real-time pricing, and remote monitoring of end-use energy efficiency and service quality.

In addition, a concept of dynamic demand bidding is discussed which, as a crucial determinant of market clearing prices of electricity, may hold promise for a more rational use of resources in the power generation sector. The paper will close with a discussion of some key market trends.

Communication Technology for Small and Large Customers

There has been a significant effort devoted to the R&D of residential gateway technology with the goal of providing information services to residential customers through utility wires or otherwise. The information services, at least in their conceptual design, encompass energy and non-energy services, whereby the non-energy services generally impose large bandwidth requirements on the transport media. There has been relatively little technology development activity for large commercial and industrial customers for economic reasons because the expected additional revenue from the sale of information services is likely to be dwarfed by revenue for electric power sales. For residential customers, the economics are much more favorable. A subscription to cable TV through a utility cable service may produce a higher revenue stream than the sale of electric power. Furthermore, the market size of individual homes is much larger than that of large commercial buildings and industrial facilities.

The first players who investigated the markets for residential gateway technology were the R&D divisions of the telephone companies and computer manufacturers, either as collaborators or as competitors. The telephone companies recognized that there are new product markets to be opened up that cater to high-tech homes whose owners are projected to desire connectivity to the Internet and other information service providers. Bellcore, General Electric, Lucent Technologies, IBM, Hewlett-Packard, and others have been actively involved with the R&D of residential gateway technology. These companies even collaborated in a joint effort to create standard protocols with the goal to generate, at least for the short term, sufficient interest to turn this technology into an economically viable product (Holliday 1996). The electric utility industry recognized only recently the revenue potential of information services. Their attempts to implement communication technologies have emerged, but more for reasons of customer retention than to create an independent revenue stream that coincides with the sale of electric energy services.

On the commercial and industrial side, the electric utilities have been very timid to invest in new product development. Real-time-pricing (RTP) has been the most frequently used information service application to date. Enerlink, a subsidiary of The Southern Company, offers an RTP communication package that provides a direct interface between the facility's energy management system (EMS) and the utility. Enerlink recognized quickly that it has to create strategic partnerships with the buildings and process controls industry to market the product effectively. Enerlink communication software integrates into Honeywell's energy management system as well as into Hewlett Packard's Vantera real-time measuring and data management system (Enerlink 1997a,b).

Communication Infrastructure is Pivotal

The current communication infrastructure places constraints on how the utilities can communicate with their customers and at what speed data can be exchanged. While sophisticated utility communication networks are in place, they are generally designed to accommodate the needs for the transmission system and distribution automation. The communication infrastructure from the distribution systems (i.e., substations) to the customer sites generally does not exist or is not sufficiently developed to provide a broad scale of information services. It is the 'last mile' in the utility/customer communication network that is the most expensive. Utilities, therefore, are very cautious in their commitment to large capital investments for new services, which the customers may or may not like. Pilot studies exploring the interest of energy and non-energy information services among participating customers did not clearly indicate that the customers are willing to pay for the new service. A recent industry survey revealed a cautious interest in information services offered by the utility. Only 25% to 45% of the more than 5000 commercial and industrial customers surveyed indicated an interest in information services such as aggregated utility billing, central energy control, central energy monitoring, and fire and security alarm monitoring (EPRI 1998).

Given the risks associated with the investment of the communication infrastructure that reaches every home, commercial building, and industrial site, the industry is likely to move forward very cautiously. Improvements are expected to be incremental with the formation of partnerships to diversify the risks among several partners. There may not be a single 'killer application' in the utility/customer communication that will generate a large infusion of venture capital, which could upgrade the communication infrastructure. It is more likely that infrastructure improvements are a consequence of small steps of incremental progress. There is little doubt that the homes of the future will be interconnected to 'information highway' with ample bandwidth to provide a large range of the information services. The question is how to get there and which path it will take.

The first of the information services that have emerged over the last years and that pose relatively small bandwidth requirements on the communication infrastructure is networked automatic meter reading (NAMR). Spurred by the restructuring in the electric power industry, inexpensive automatic meter reading technologies have been developed with the logistic and data management systems that allow hundreds of thousands of meters to be read and processed by one system.

The messages to be transported over the network are small in size and are generally not time critical. Hourly electric consumption is logged in the meter and uploaded once a day, week, or month or on demand. Given the state of the current communication infrastructure, radio frequency transmission has emerged as a cost-effective medium for wide area coverage of NAMR services. Recently, new services have been added to the meter reading task that include power quality monitoring, outage detection, remote service connect and disconnect. These services can generally be accommodated by the existing communication systems because the message size and transmission frequency are small.

Overview of Currently Available Energy Information Services

Networked Automatic Meter Reading

The objective of NAMR is to transport meter data from the customer site to the utility. The meter from which measurements are taken could be an electrical, natural gas, or water meter. The service may be provided by a distribution company or by a new emerging market entity, the meter reading provider.

In preparation for the deregulation of the electric power industry, intense debate among the stakeholders in the metering industry have produced detailed specifications of physical properties to be metered as well as communication protocols and requirements for the transport of metering data across wide-area-networks (WANs). It is commonly viewed that proprietary and non-standard metering technologies are a competition impediment. They inhibit the free choice of meter reading agents and, more importantly, of the energy provider that needs to read the customers' meter.

On March 6, 1997, the California Public Utility Commission (CPUC) ordered the three large investor owned utilities Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE) to confer with interested parties and to develop the necessary standards for equipment and functions to ensure that reliable service to customers would continue, regardless of the metering service entity[2]. The Metering and Data Communication Standards (MDCS) working group was founded as a result of this CPUC order. The working group submitted their report to the CPUC in July 1997. This report is one of the most comprehensive documents on the metering and data communication issues (MDCS 1997). This working group report, in addition to Automatic Meter Reading Association (AMRA) and Institute of Electrical and Electronics Engineers (IEEE) standards (AMRA/IEEE SCC31), provides procedural guidelines and technical standards to develop metering and open and standard communication technology that facilitates free choice of service provider.

NAMR companies have emerged with technology and data management offerings that support the reading of hundreds of thousands of the meters. Most of them are based on wireless communication technologies that communicate to the meter via digital or analog radio signal or over the power lines. Cellnet and Itron are two of the large full service NAMR providers. The NAMR market is rapidly growing because of the need to flexibly read electrical meters as customers may switch energy service providers in a deregulated electric power market. Innovative communication technologies are being developed to transmit meter data over cellular telephone channels during low utilization periods.

[2] PG&E, SDG&E, and SCE (the UDCs) were ordered by Decision 97-05-039 (Ordering Paragraph 4) and Decision 97-05-040 (Ordering Paragraph 7.A.(1)), dated May 6, 1997.

Quality of Service Monitoring

The transmission of indicators for quality of service can often be accommodated by NAMR communication technology and thus is offered in conjunction with the meter reading services. Quality of service monitoring encompasses power quality, service reliability and outage detection of electrical services as well as pressure transients and service disruption of natural gas and water supply lines.

Power Quality Monitoring: Power quality monitoring provides the ability to monitor key power quality parameters for the purpose of establishing a common base for the nature and extent of power quality disturbances. To be effective in identifying and mitigating power quality problems, power quality is monitored at the customer's service entrance and within the customer's facility for the purpose of isolating the origin of the power quality disturbance. Included in the power quality service are unsolicited power quality event reporting, power quality event staging, local power quality event storage and retrieval, and device synchronization throughout the WAN.

Service outage/disruption detection: The objective of outage and service disruption detection is to report service outages and monitor time and date of power outage or supply disruption. This service is applicable for power as well as for natural gas and water services. This service provides the utility with rapid information on the extent of a power outage or service disruption.

The power quality and service outage detecting can often be accommodated by NAMR communication technology. Information on power quality events is reduced to key parameters that characterize the event rather than sending power transient information over the network.

Direct and Price-Induced Load Management

Direct load management methods have been applied in the residential sector by turning off energy intensive air-conditioning units for limited hours to reduce the utilities' system demand peak during critical low reserve margin periods. The most common way to cycle off residential air-conditioning equipment is to use relay switches that are activated via radio transmission. The residential customer is generally rewarded through an incentive tariff. In the industrial sector, interruptible services are common and can interrupt an entire electric feed to the industrial complex. The breaker switch is also remotely controlled by the utility.

Time-of-use (TOU) rates or real-time-pricing (RTP) rate structures induce peak load reduction or shift electricity consumption from peak to off-peak periods by means of economics. The control actions for load management are initiated from within a building or facility through means of energy management and control systems. It is the building/facility engineer who decides how to manage the loads. Flexible and dynamic load limiting functions have recently been automated in sophisticated energy management and controls software for residential, commercial, and industrial customers.

Residential Application: A common communication solution for load shedding measures with residential customers is to broadcast a load relief signal that is received by a transceiver, which turns off energy intensive equipment. American Electric Power (AEP) is currently conducting a small-scale pilot study with a communication technology called TranstexT. AEP offered TranstexT to about 250 residential homes as a hybrid two-way communication and home automation technology that enables participating customers to develop electric load management strategies according to price signals sent from AEP. TranstexT encompasses two communication devices (transceiver and dial out modem) to communicate with the utility and a home automation network based on the CEBus [3] protocol and small logic unit that provides programmability for load management strategies and data collection. The communication from the utility to the TranstexT homes is established by AEP's 800 MHz radio transmitter. The radio transmitter has high output of 100 Watt reaching all participating homes. The return communication from the homes to AEP is established via telephone lines and dial-out modem resident in each home unit.

The home automation system uses the CEBus protocol over the powerline in the home and is controlled by a central control unit. The central control unit is connected to the dial-out modem for downloading zone temperatures, thermostat set points, and electric energy consumption (kWh) for the entire home and for selected electrical appliances (such as washer, dryer, dishwasher, electric water heater, and electrical heat pump). The dial-out is programmed to a set schedule or at request by the utility over radio frequency transmission. The home automation system provides controllability to shut off home appliances based on the price of electricity.

The rate structure of the pilot program is based on a four tier TOU tariff system. Three of the four tariffs are determined on a set schedule. The fourth tier is invoked under critical low reserve margin conditions when the utility requires load relief from the demand sectors. Under the critical condition, AEP broadcasts a '*change of tier*' message, which overrides the current tier that is in effect and shuts off designated electric appliances to shed loads.

Lucent Technology tested a residential gateway with a New Jersey utility, Public Service Electric & Gas (PSE&G). This pilot study was unique in that PSE&G provided real-time-pricing information to the residential customer to encourage load management activities. The commercialization of the initial residential gateway prototype is currently pursued by Comverge, a new company that was spun off from Lucent Technologies Utility Solutions. Comverge's Customer Connection provides real-time two-way communication between the utility or energy provider and the residential home. It is entirely based on open communication standards and, thus, compatible with current network infrastructures. The gateway provides connectivity to the home's LAN using the CEBus protocol. The CEBus local area network (LAN) can be established over the power lines, twisted pair, or radio frequency transmitters. The gateway communicates with the utility's data and communication management subsystem over the WAN using the Utility Communications Architecture (UCA) protocol. The WAN can be established using hybrid fiber optics and coax cables (HFC), Cellular Digital Packet Data (CDPD), or telephone lines. The gateway technology has sufficient processing power to load third-party applications to perform various control measures. The residential gateway was designed to facilitate the following services (Comverge 1998):

[3] CEBus is the Electronic Industries Association's (EIA's) standard for home automation.

- automated meter reading
- direct load management by the utilities
- customer controlled load management
- real-time pricing messages
- remote outage detection
- remote service connect and disconnect
- tamper detection.

Comverge's new technology is currently being implemented in a pilot program with the Volunteer Electric Cooperative in Tennessee with 25 participating homes. The final installation was completed in the Spring of 1998. The emphasis of this pilot is to test load management strategies by supplying real-time-pricing information to the customers. The main target of the load management is to optimally use the electrical water heater such that the cost of electricity is minimized. The Cooperative will gain knowledge of the price responsiveness of the participating customers. The Consolidated Edison Company (ConEd) in New York City is also experimenting with Comverge's technology in ConEd's Learning Center. The Learning Center is an approximate 100,000 ft^2 commercial building located in New York. ConEd's interest in the technology is to gain experience in accessing metered electricity data via the Internet.

Under the European Commission funded European Telematics Horizontal Observatory Service (ETHOS) umbrella, the load management system (CELECTR) is being tested in large field trials. It involves 763 homes in four European countries. (UK - 285, Denmark - 100, France - 270, Italy - 108). CELECTR is a UK-developed load controller designed for electric space heaters with thermal storage to optimize the charging and discharging cycles under cost minimization principals. It requires a daily weather forecast to perform a load prediction for the next day. The electric rate for all homes is a time-of-use rate. CELECTR has been extended in its functionality to control the operation of water heaters and washers and dryers. The weather forecast is transmitted over a long wave radio transmitter and received at a residential gateway that communicates to CELECTR via the European home system (EHS) protocol. The objective of this project is to field test the effectiveness of the load control and to gain experience with the EHS communication protocol as a European standard for home automation. The project was started in 1995 and will run to the end of 1998. The European Commission has committed major financial resources toward the establishment of home automation standards including gateway technologies.

Commercial and Industrial Applications: For the commercial sector, Honeywell has offered RTP controls and communication software that receives the real-time-price signals directly from the utility via a customer communication gateway (CCG™). Under the sponsorship of the Electric Power Research Institute, Consolidated Edison Company, Empire State Electric Energy Research Corporation, and the New York State Energy Research and Development Authority, Honeywell has developed a communication and control system that completely automates the operation of commercial and industrial facilities in response to RTP.

Honeywell showcased this technology at the Marriott Marquis in New York City in 1995 and accrued first year's savings of $100,000 (ELECTRICAL WORLD 1996). Sophisticated load shedding measures were applied to reduce the peak demand up to 1 MW during high price periods. The energy management and control system performs control measures in response to electricity prices. These control measures include dimming of the lighting, temperature setbacks, pre-cooling during early morning hours and shifting of electrical equipment to low price hours.

The World Financial Center in New York City is another facility equipped with the Honeywell RTP technology. This facility has an ice-storage that is controlled using an optimization approach that determines an optimal charge and discharge protocol that minimizes the cost of electricity. Other applications of the Honeywell technology are the Emory University Hospital in Atlanta, the Atlanta International Airport, and buildings at the McCormick Company and at AT&T both in Hunt Valley, Maryland.

The numerous projects using the Honeywell technology provided valuable insights into the project conditions necessary for RTP to be successful. The Hunt Valley projects, McCormick facility and the AT&T building, showed that with limited control options, the benefits from RTP were marginal. RTP can be successfully applied with industrial customers when there is sufficient flexibility to manage loads by interrupting industrial processes or shifting work schedules flexibly. Load management in commercial buildings concentrate on lighting and heating, ventilation, and air-conditioning (HVAC) control strategies because they contribute significantly to the total building demand and are changeable. Prerequisite for effective load reduction and load shifting is thermal storage equipment. The thermal mass of the building can also be utilized for load management measures. In thermally light buildings with little thermal mass and without thermal energy storage equipment, the HVAC load management remains marginal.

Potential Future Energy Information Services

Weather Forecast

The utility or energy service provider is likely to offer a local weather forecasting service that is specific to the customer's location. The weather forecast is broadcast to the subscribing customers with hourly updates. The forecast includes hourly air temperatures, humidity, wind information, precipitation, and cloud cover for the next 24 hours. There may be local weather differences such that the weather forecast provider may offer a customized weather forecast that is adjusted for proximity climate differences. Weather forecast with micro level adjustment will result in a very accurate site-specific forecast suitable for short-term load prediction.

Remote Efficiency Monitoring

The objective of this service is to reduce the cost of energy by monitoring total building and end-use energy efficiencies. The service identifies degradation of energy efficiency of individual end-uses such as heating, cooling, ventilation, and lighting. Consumption data are processed to produce appropriate efficiency indices that reveal degradation in the facility's energy efficiency. Service providers may offer this service to their customers or larger corporations may perform this service enterprise-wide for cost saving reasons. The system evaluates energy efficiency indices for many facilities and buildings. Relevant energy indices could be evaluated that are normalized by total building/facility or zone floor space and by the number of occupants. Indices should be weather adjusted to provide a common basis for long-term trending and comparisons.

Load profiles provide key information from which demand reduction measures can be derived. Load parameters such as load diversity and the ratio of monthly building/facility demand peak to wet bulb temperature or solar insolation can be used to describe the load profile characteristics.

There are two viable approaches to achieve the energy efficiency monitoring objective. First, detailed consumption data of subsystems and equipment set points are transmitted from the buildings/facilities to an energy control center to be processed. This would require a significant amount of raw data to be transported over the WAN. Alternatively, the raw data are processed and energy indices are determined on-site and only the indices are being reported to the control center. There are challenges to either approach. To transmit detailed end-use consumption data, a uniform representation of consumption and equipment set point data must exist across all existing energy management and control systems (EMCS) used by subscribing customers. Because there are many different data structures implemented in today's existing EMCS, a gateway must be devised to properly access the database information. New efforts of the BACnet Standing Standards Committee of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) address this issue and propose standards for an EMCS database structure.

The challenge of evaluating energy efficiency indices at the local EMCS is associated with the automation of this service. It would require software maintenance that would account for updating floor space as the building undergoes extensions or changes in the leasing arrangements. For weather normalization, either outside conditions must be measured by the EMCS or an automated weather service provider must transmit weather data to the local EMCS. From a computational point of view, it is advantageous to distribute the data processing to the local EMCS and transmit the results rather than transmit large amounts of raw data over the WAN.

Trouble Shooting/Diagnostics

The objective of this service is to save labor cost for on-site maintenance staff or maintenance contractors by identifying system areas where a fault or a technical problem occurred. Furthermore, predictive maintenance can be performed by recognizing deterioration of the equipment performance and calling for maintenance before a catastrophic system failure occurs. This service has the greatest potential for buildings/facilities that are remote, where travel to and from the building/facility involves significant cost.

Indoor-Air-Quality (IAQ) Monitoring/Auditing

The objective of this service is to document IAQ conditions for purposes of conflict resolution for sick building syndrome claims, regulatory indoor air quality compliance, or advertising IAQ attributes of commercial real estate.

Dynamic Demand Side Bidding (DDB)

The DDB service is envisioned to provide a two-way information exchange between an energy service provider (ESP) and a customer. The DDB service will furnish the ESP detailed information on customers' ability to respond to electricity price differences. This information could be used for submitting a power purchase bid to a power exchange. The DDB service discussed herein will be based on the new California power market. A brief overview of the bidding process at the California Power Exchange (PX) follows.

One of the new entities in the California power market is the Power Exchange (PX), whose primary purpose is to provide an efficient and competitive electric energy auction open to all suppliers of electricity for the purchase of power at market prices. The PX will accept demand and generation bids from its participants and determine the market clearing price (MCP) at which energy is bought and sold. The MCP is determined by the intersection of the aggregated system-wide demand and supply curves. The balanced demand and supply schedules at MCP for the successful bidders are then submitted to the Independent System Operator (ISO) for review of transmission line congestion. The PX will have two bidding markets: (1) one day-ahead-market and (2) one hour-ahead-market. The MCP is determined for both markets using the same method. The PX electronically communicates price and traded quantities to PX participants immediately after the market is closed.

Participants in bidding process can be: (1) utility distribution companies (UDCs), (2) retailers, (3) energy service providers and load aggregators, (4) large customers desiring direct access to transmission lines, (5) power marketeers, (6) generators.

These participants (except the generators) bid a demand schedule to the PX. A demand schedule defines the elasticity of electric demand with respect to price. As such it characterizes the ability of end-users to reduce loads at increasing electricity prices . The UDCs, ESPs, and load aggregators bid a demand schedule that represents the sum of all of their individual customers. Each purchaser of electricity provides a demand schedule, which will be aggregated by the PX to one curve representing the entire system demand.

In a dynamic market in which customers may frequently change their ESP (similar to long distance telephone services), it may be difficult for an ESP to determine an aggregated demand curve. The DDB service adopts a bottom-up approach that places the responsibility of determining the price-elasticity in the hand of each customer who knows best what loads can be shed under any given circumstance. Rather than estimating the aggregated load directly using aggregated historical load data, the bottom-up approach provides robustness in a constantly changing environment. It is very likely that the price-elasticity may change on a daily/weekly/monthly basis as the building's occupancy or the facility's process planning schedules change. The transfer of each customer's demand curve is proposed to be automated via the communication link between the customer and the ESP.

Service objective: The DDB service will provide a dynamic information exchange between individual customers and ESPs to perform the following two functions:

1. The energy service provider requests up-to-date demand schedules from each customer to determine the demand schedule representing the entire aggregated load. The ESP bids the aggregated demand curve to the PX.

2. After the MCP is determined by the PX, the energy service provider may purchase electric power based on its demand schedule at the MCP. For this power purchase to be sufficient, each customer is required to perform the necessary load management strategies to stay within the load target as determined in the customer demand schedule. The ESP will broadcast to each customer the hourly MCP, which is then processed by each customer's EMCS to evaluate an hourly load limit. The energy service provider monitors each customer's total load and applies a penalty in cases of non-compliance with the submitted demand schedule.

The regulations pertaining to the operations of the California PX prescribe procedures that would require several bid iterations. An iterative bidding process becomes necessary in cases in which the selection of the successful bidder for generation services leads to interzonal transmission congestion. The ISO identifies transmission congestion. When transmission congestion is detected, incremental supply schedule changes are necessary. The bidding process is then repeated given the constraints for transmission congestion avoidance. Likewise, the DDB service is repeated incorporating the newest updates from the load forecasting and potential changes in the building or facility schedules.

Market Trends

There are several market trends emerging in the energy information service area. First, there is significant activity in standardization efforts to specify standard communication protocols that allow a third party market to evolve. Standardization is taking place in the home automation area with CEBus and the European EHS. The Utility Communication Architecture (UCA) encompasses proposals for specifications for supervisory control and data acquisition (SCADA) and WAN energy management applications. The specification of UCA is a collaborative effort involving several working groups that focus on customer interfaces, generation, and distribution automation. The major thrust of the standardization activities, nationally and internationally, comes from the recognition that competitive power markets need seamless communication services within the power supply sector and between the demand and supply sectors. Interoperability among communication systems becomes necessary to flexibly connect and disconnect energy services as the customers exercise their free choices of fuels and energy providers. Although significant market inertia in the utility's WAN EMS still exists and will be for some time, proprietary communication protocols and database structures will eventually give way to standard protocols and open system architecture. Because of the significant capital investment in the information and communication technology, the change over is expected to be slow.

For the utility/customer interface, there are significant market forces that require seamless and robust communication solutions. Utilities will become interested in distributed generation concepts that utilize idle emergency generator capacity of large commercial, institutional, and industrial customers. To utilize this capacity, control and communication technology must be installed that provide controllability of remote generators over wide area networks. New market entrants in the competitive power markets, such as load aggregators or national energy providers, ask for communication and control technology that allows them to optimally manage their loads to improve their bottom-line. With flexible procurement of electric power, these companies are likely to develop optimal fuel switching and power supply strategies that require them to understand the load requirements of each participating customer in their load pool. Remote monitoring and control of buildings and facilities will enable them to access the detailed information on each individual load and to perform the appropriate control strategies. Load prediction and scheduling of manufacturing processes and other energy intense events are likely to be part of the control capabilities. Remote diagnostics of HVAC equipment are being developed to identify energy efficiency degradation. Predictive maintenance strategies of building systems utilizing communication systems for detailed systems data analysis and alarm notification are likely to yield short term cost savings by reducing labor cost for buildings operation. Cost savings resulting from energy efficiency improvements are realizable. However, the largest savings component may be attributable to load management and energy procurement strategies.

Research is being conducted to support WAN communications for remote building monitoring and control and dynamic demand-side management strategies. Lawrence Berkeley National Laboratory researchers are testing building remote monitoring and control systems on-line over the Internet (Olken 1996[4], 1997). The International Energy Agency (IEA) and ASHRAE are conducting research to investigate an automated fault detection and diagnostic system for HVAC equipment. ASHRAE is also funding research that investigates communication requirements for the information exchange between the utility and commercial and industrial customers. Recently, the IEA has announced a new research project that will investigate the potential for dynamic demand side bidding in a competitive power industry and the technical requirements to implement such a process.

Energy, energy pricing, and billing information are considered proprietary. As a consequence, access to these data must be secured. Furthermore, as energy information is transferred and shared among several businesses (e.g., a company that reads the meter, a company that writes the bills, and a distribution company), stringent access privileges and provisions that provide an audit trail regarding the history of the data must be in place. Data security for consumer protection and communication security for an increasing level of automation in the procurement and control of electric power will require significant technical efforts as well as regulatory solutions at the state and Federal level.

Conclusions

Competitive energy markets are the driving forces for the implementation of information technology and improvements to the communication infrastructure. To date the networked automatic meter reading service is expected to be, at least for the short-term, the most widely applied information service that will bring about a significant broadening of the communication infrastructure such that each home, building, and industrial facility will be connected to the utility.

The business model of strategic partnerships among the utilities, energy service provides, cable industry, and telephone companies is expected to continue to share the risk in the expensive communication infrastructure improvements. New technological advancements will spur new service

[4] Olken, F., C. McParland, M. Piette, D. Sartor, and S. Selkowitz, "Remote Building Monitoring and Control." May 17, 1996. ACEEE Draft.

offerings and, in turn, the lessons learned through the implementation of services will induce technological progress. There may not be a single 'killer application' in the utility/customer communication that will generate a large infusion of venture capital sufficient to upgrade the communication infrastructure to bring fiber-optics cables to each customer. It is more likely that infrastructure improvements are a consequence of small steps of incremental progress. There is little doubt that the homes of the future will be interconnected to an 'information highway' with ample bandwidth to provide a large range of the information services. The question is how to get there and which path it will take.

Utility/customer communication and advanced controls may first find market acceptance in the commercial and industrial sector as part of energy savings performance contracts before we see large acceptance in the residential sector. The potential of large scale remote monitoring and diagnostics promises relatively short-term cost savings opportunities mainly because of labor cost savings. Energy savings are likely because of the increased awareness of how energy is used and by avoiding wasted energy. Advances in the communication technology will provide the necessary information to perform optimal control strategies enterprise-wide, including many buildings and facilities. Cost savings opportunities using optimal load management and optimal procurement of energy, including risk management, will be the major driver to the wide adoption of new technology in the market place.

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